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Italian households' willingness to pay for green electricity

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ABSTRACT

The EU directive 2009/72/CE imposes environmental and energy targets on European countries. The goal of Italy is to attain 26.4% green electricity (GE) production from renewable energy sources (RES) by 2020. This goal imposes an extra cost on households; consequently, it is important to estimate their willingness to pay (WTP) to attain this target. Our research is based on a nationwide survey of households conducted in November 2007 in Italy, explicitly considering uncertainty and the compulsory burden on the electricity bill. The results obtained with different models indicate that there is a noticeable WTP among Italian households for the GE goal and that estimated WTP differs according to uncertainty. Indeed, median WTP is between 4.62 EUR and 8.05 EUR every two months per household. Finally, the relevance of these findings today has also been discussed.

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1. Introduction

Despite the recent financial crisis, an increase in renewable energy remains an important goal for Italian citizens. Indeed, as highlighted in the Eurobarometer survey [1], the share of Italian residents that are in agreement with the goals of the EU directive

Abbreviations: BB, Broberg and Brännlund approach; CE, choice experiment; CS, compensating surplus; CV, contingent valuation; DN, definitely no; DY, definitely yes; DBDC, double bounded dichotomous choice; DK, do not know; GE, green electricity; MBDC, multiple-bounded dichotomous choice; PC, payment card; PN, probably no; PY, probably yes; RES, renewable energy sources; SB, single bounded; SPC, stochastic payment card; WP, Welsh and Poe approach; WTP, willingness to pay

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Table 1
WTP for GE, related literature (studies that include GE policy program).

Author	Country	Data year	Sample size	Survey	Method[a]	Main findings[b]	Uncertainty correction	Annual WTP/household[c]
Bigerna and Polinori [19,20]	Italy	2007 November 2008 November	1600	Internet	Bidding game; interval regression.	Target: 26% of GE by 2020 [+11%]. Mean households' WTP: 40.9–50.4 EUR per year. Nearly 35% of target cost.	Ex post; numerical likelihoods	From 40.9 to 50.4
Kim et al. [24]	Korea	2010 August	720	Field inter-views	DBDC; spike model.	Target: renewable portfolio standard by 2012. Mean households' WTP: 1.35 USD per month. Almost 58% of government budget for renewable program.	No	12.12
Grösche and Schröder [13]	Germany	2008	2948	Internet	CE; random parameters model.	Target: 30% RES scenario [+15%] replacing nuclear with RES by 2020. Median households' WTP 2.03 ¢EUR/kWh; 2.37 ¢EUR/kWh if fossil fuel is also replaced.	No	69.30; 80.85[d]
Bollino [17]	Italy	2006 November	1601	Internet	SPC treated as dichotomous choice model; probit.	Target: 22% of GE by 2010 [+7%]. Mean households' WTP: 2.44–9.39 EUR every two months. From 16% to 61.5% of target cost.	Ex post; numerical likelihoods	From 15 to 57.66
Yoo and Kwak [26]	Korea	2006	800	Field inter-views	DBDC; spike model; non parametric approach.	Target: 7% of GE by 2011 [+6.8%]. Mean households' WTP: (a) 1.8–2.0 USD per month; (b) 1.6–2.7 USD per month. Annual benefits from 150.5 to 194.2 million USD.	No	(a) From 16.92 to 19.08 (b) From 15.84 to 25.56
Ivanova [27]	Australia	2004 August	213	Mail	SB open ended; regression analysis.	Target: mandatory renewable energy target, 12.5% [+2%]. Mean households' WTP: 22 AUD per quarter if policy support; 28 AUD per quarter if voluntary payment.	No	50.59; 69.44
Batley et al. [28]	UK	1997 March 1999 April	742,692	Mail	SB open ended; correlation analysis.	Target: national goal of 10% GE according to Climate Change Draft UK program. Households' WTP: mean premium 16.6% (34% of citizens sample); mean premium 18.5% (34.86% of consumers' sample).	No	70.90; 74.07[e]
Batley et al. [30]	UK	1999 March	746	Mail	SB open ended; multiple regression and factor analysis.	Target: national goal of 10% electricity by RES according to Climate Change Draft UK program. Households' WTP: mean premium of 19.11% (35.85% of consumers' sample).	No	76.72[e]

[a] Choice experiment (CE), double bounded dichotomous choice (DBDC), single bounded (SB), stochastic payment card (SPC).
[b] GE share increase in square brackets.
[c] EUR 2007.
[d] We assume a consumption of 3500 kWh per year in 2008 [25].
[e] In UK annual electricity bills, for a typical household, were 283 GBP in 1997 and 266 GBP in 1999 [29].

2009/72/CE[1] has been greater than 64% on average since 2008. Renewable energy sources (RES) are considered to be important to green electricity (GE)[2] production to reduce pollutant emissions and to preserve fossil fuel. These pros are balanced by uncertainty in electricity generation and by high cost of supply and generation that prevent the widespread uptake of GE, and consequently, public funding is needed to support its development. If consumers take environmental issues into account, they are likely to increase the premiums that they are willing to pay for GE, reducing the need for public financing over time. In this context, it becomes important to estimate the extent of this price premium to assess how the market is able to support GE policy while considering some crucial elements.

Firstly, in the GE market, uncertainty characterizes the institutional context [2], and influences both the supply side (generation included) [3] and the demand side [4]. In addition, the stated preference method is itself characterized by uncertainty [5–9]. Nevertheless, few scholars have explicitly included uncertainty in their contingent valuation (CV) studies on GE [10,11]. In this paper, among several sources of uncertainty associated with the evaluation process [5], uncertainty related to an individual's preferences and characteristics is dealt with using ex-ante and ex-post uncertainty bias correction methods [12].

Secondly, in Italy, subsidies are paid by all customers through a feed-in tariff mechanism. In other words, all consumers pay for an increasing share of RES, which reduces consumers' sovereignty as occurs in many others network regulated markets. To the best of our knowledge, with the exception of Grösche and Schröder [13], previous studies have not considered that people are committed to paying for GE. In our questionnaire, respondents are informed about the feed-in tariff mechanism. Finally, there are several types

[1] This directive known as the "Climate and energy package", sets three targets for 2020 (known as "20–20–20"): 20% reduction in pollutant emissions, the achievement of an energy portfolio with a 20% share of renewables and 20% energy consumption savings. According to this directive, the goal of Italy is to attain a 17% share of that is 26.4% of electricity produced by RES.
[2] In Italy GE and RES are referring mostly to the same concept. In fact, RES are primarily used to generate electricity.

Table 2
WTP for GE, related literature.

Author	Country	Data year	Sample size	Survey	Method[a]	Main findings	Uncertainty correction	Annual WTP/ Household[b]
Zhang and Wu [31]	China	2010 May–June	652; 536	Email and mail	CV; PC; mixed-logit.	Mean households' WTP: 1.15–1.51 USD per month.	No	From 10.80 to 14.16
Zoric and Hrovatin [32]	Slovenia	2008	450	Internet and field interviews	SB open ended; tobit, probit; truncated regression.	Mean households' WTP: 4.2 EUR per month; Median 4 EUR per month.	No	49.08; 46.68
Hanemann et al. [33]	Spain	2009 November–December	233	Phone	SB	Median households' WTP: 29.91 EUR per month	"Do not know" option	346.20
Hansla et al. [34]	Swedish	2008	855	Mail	PC; regression analysis.	Households' WTP: sample majority 0.001–0.02 SEK/kWh.	No	From 8.90 to 17.80[c]
Borchers et al. [35]	US	2006 May	625	Field interviews	CE; nested logit model.	Mean households' WTP: (a) 1.08–21.54 USD per month depending on scenarios proposed and green sources; (b) 8.44–17.00 USD per month for generic GE depending on payment methods and scenarios[d].	No	(a) From 10.28 to 205.10 (b) From 80.40 to 161.87
Nomura and Akay [36]	Japan	2000 October	379	Mail	DBDC; Weibull distribution function.	Median households' WTP: 2000 JPY per month.	No	283.44
Goett et al. [37]	US	2000	1205	Phone and mail	CE; mixed-logit regression.	Mean households' WTP: 0.0145 USD/kWh, 100% wind; 0.02 USD/kWh 100% hydro.	No	195.67; 269.74[e]
Byrnes et al. [38]	US	1992 September 1994 November	600,500	Phone and mail	CE; censored regression.	Mean households' WTP: 1.63; 1.72 USD per month.	No	17.64; 19.44

[a] Choice experiment (CE), contingent valuation (CV), double bounded dichotomous choice (DBDC), payment card (PC), single bounded (SB), stochastic payment card (SPC).
[b] EUR 2007.
[c] We assume a consumption of 8900 kWh per year in 2008 [25].
[d] Voluntary and mandatory payments are considered; hypothetical scenarios with 10% or 25% of RES are proposed.
[e] We assume a consumption of 11,055 kWh per year in 2000 [25].

Table 3
Component A3–2007[a].

Features	Low voltage				Medium voltage		High voltage	
	Households		Others					
Committed power (kW)	3	3	10	100	500	1000	3000	10,000
Use (hours per year)	880	1167	1200	1500	2000	2500	2500	3500
Annual consumption (MWh)	2.64	3.5	12	150	1000	2500	7500	35,000
Average rate A3 (¢EUR per kWh)	0.73	0.75	1.21	0.93	0.75	0.74	0.68	0.67
Monthly expenditure (EUR)	1.6	2.2	12	116	627	1545	4236	19,481
Only RES	*0.95*	*1.3*	*7*	*69*	*370*	*913*	*2502*	*11,507*
Tax levy (million EUR)	630		1228		1192		279	
Total (million EUR)	3329							

[a] Our elaboration on data provided by Gestore Servizi Energetici (Italian Electricity Services Operator).

of customers in the electricity market that differ in terms of usage, the type of consumption and the amounts of the electricity bill. In this paper low-voltage uses households, being the most numerous, are only considered.

The aim of this paper is to estimate households' willingness to pay (WTP) for GE explicitly taking these issues into account. Aggregate WTP obtained from CV studies is compared with cost of the 20–20–20 Italian GE target to assess its market sustainability. Furthermore, we increase knowledge on GE by examining related households' perceptions, knowledge and attitudes in Italy.[3]

[3] Some studies tackle with households' preferences and attitudes towards green energy. See among others Cicia et al. [14] and Strazzera et al. [15].

2. Methods for valuing GE

Several studies have focused on GE valuation from different points of view, such as [16] (a) economic and welfare, (b) financial, and (c) ecological and engineering perspectives. Our contribution belongs to the first type of studies because an aggregate WTP is estimated to appraise if it is possible to achieve the Italian directive 72/2009 target by 2020 with market forces. In accordance with this aim, we investigate related literature on GE in mainly selecting papers that estimate WTP to develop GE according to policy programs to evaluate their market financing capacity (Table 1). However, papers that provide aggregate or individual WTP are also reviewed for completeness (Table 2).

In Table 1, studies that explicitly take into account a quantitative policy target are considered. Using several elicitation formats, scholars find generally low financial economic support of GE, with Italy being the only exception, according to Bollino's [17] results. Comparing annual households' WTP at constant prices (EUR 2007),[4] we notice that a very wide range of values exist in Europe and in the USA. Restricting the analysis to Europe, the annual amount ranges from 8.90 EUR in Sweden to 346.20 EUR in Spain. In the USA, depending on the energy sources, policy program and type of payment, the annual WTP per household ranges from 10.28 EUR to 269.74 EUR. These intervals are narrower if countries with a more comparable electricity market, such as Germany, Italy and the UK [18], are considered. In these cases, annual amounts lie between 15.03 EUR and 80.85 EUR, depending on the uncertainty and energy mix. Regardless of the energy mix used in GE production, uncertainty plays a crucial role in the WTP, as shown in a few studies that consider this issue. Vossler et al. [10] find that in a pricing program, certainty correction accounts for 9.5% to 75% of the uncorrected WTP in the dichotomous choice model, while in the multiple-bounded dichotomous choice (MBDC) approach the less conservative model provides a WTP four times greater than that of the conservative model. In Bollino's [17] study, uncertainty accounts for 8.5–45.5% of the cost of reaching the Italian target. Similar results are obtained by Bigerna and Polinori [19,20] when also controlling for different elicitation formats.

Different methods have been used to introduce uncertainty in CV studies; one of the many possible ways is to combine ordinary payment card (PC) and polychotomous choice questions [9]. This method has been employed by Welsh and Poe [21] and Alberini et al. [22], who directly incorporate certainty levels into the discrete choice decision framework. In other studies, the introduction of certainty levels can be regarded as an ex-post adjustment to the dichotomous choice response [23]. Using the GE pricing program, Vossler et al. [10] explore these methods using a field validity test to compare the findings of Champ et al. [23] with those of Welsh and Poe [21], but the results do not provide a definitive answer of which of these methods is preferable.

2.1. GE in Italy

The IEA's World Energy Outlook 2012 [39] predicts that renewable energy will become the world's second largest source of electricity generation by 2015, and by 2035 renewables and coal will become the main source in the fuel energy mix. In this context, Europe plays a leading role, and according to the New Policies Scenario,[5] GE is expected to increase from 24% in 2010 to 44% in 2035. Among the leading countries in Europe, Italy has increased its share of GE becoming the world's second largest GE producer after Germany. Italy is also among the top five countries for total investment in renewable energy and the top seven countries for non-hydro renewable electricity capacity [40]. Focusing on GE, Italy is a leading member state in Europe, with Italy, Germany, Spain, France, the UK and Sweden together providing 70% of the EU27 production [41]. The leading position of Italy in these contexts is explained by public expenditures and support policies.

In Italy, support mechanisms are mixed, and in the context of market liberalization, they impose a burden on the bills of both households and businesses. Incentive mechanisms are based both on market regimes (such as the quantity-oriented mechanism or "green certificates") and administrative regimes (such as the price-oriented mechanism or "feed-in tariffs", capital incentives and tax credit incentives). In particular, these mechanisms include the following: (a) incentive rates for renewable energy and assimilated sources (before 1999); (b) a system of green certificates for RES (since 1999); (c) a system of feed-in tariffs for renewable energy installations to power less than 1 MW (200 kW for wind power) since 2005; (d) a feed-in premium for solar power plants, particularly for photovoltaic systems (since 2007); and (e) capital grants (local) for some renewable sources (since 2003). However, government intervention through taxes and subsidies translates to higher electricity prices in the short run. In such a setting, it becomes crucial to explore the WTP for GE, taking into account that consumers are already paying part of the cost to increase the share of RES in the fuel electricity mix. In our questionnaire the respondents are provided with this information.

2.2. The cost of GE in Italy

Since 1997 (decree 70/97, Regulatory Authority for Electricity and Gas), there has been a component of electricity bills in Italy (named A3) that also covers the cost of RES used in electricity generation. Beyond the RES component, A3 includes subsidies for power plant production based on conventional fuels by alternative production techniques (e.g., alternative fuel processing and waste processing techniques and the use of industrial production in generation). Consequently, component A3 (Table 3) overestimates the actual support provided for RES. In 2007, component A3 amounted to 3300 million EUR, representing a mean additional cost that lies between 1.60 EUR and 2.20 EUR per month per household, but if fees and charges strictly related to GE are considered, these figures decrease to between 0.95 EUR and 1.30 EUR. This information is used to make interviewees aware of the compulsory burden on their electricity bills. Finally, for the aim of this paper, it is important to estimate the cost to attain the target 26.4% of electricity produced using RES by 2020. In Italy, among several estimated figures, the amount of 3500 million EUR per year according to Center for Research on Energy and Environmental Economics and Policy [42] is used.

2.3. Survey method and questionnaire

To derive estimates of households' WTP, a nationwide survey with 1019 interviews was administered at the end of November 2007 using a stratified sample that is representative of Italian residents (see Appendix C). The survey was conducted by Istituto Piepoli, a marketing and consulting company, using a computer-aided web interviewing method. The full raw data set was

[4] Information on exchange rates and deflators are gathered by websites Blomberg.com and Oanda.com.

[5] A scenario in the World Energy Outlook [39] takes into account broad policy commitments and plans that have been announced by countries, including national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-energy subsidies, even if the measures to implement these commitments have yet to be identified or announced.

transferred to the authors for this research, so on principle, no hidden non-stochastic distortions (such as recoding mistakes) should affect the results.

A preliminary analysis was conducted in May 2007 by a focus group composed by energy managers, experts, members of energy authorities and academics. Their experience and knowledge permit to avoid value judgments and consumer confusion that typically affect the GE market [43–45]. Indeed, the focus group is used to define the price vector to take into account potential biases associated with the PC method [46], obtaining an unbiased economic valuation of GE and a more reliable WTP. Validity test questions are also used to mitigate the consumer confusion [43,44]. Respondents were first asked if they know about GE, and then, respondents were asked to identify RES among a set of energy sources. In this way, we follow Soderqvist and Soutukorva [47] in highlighting the importance of the description and understanding of the valuation scenario and how people are directly or indirectly affected by the environmental change proposed.[6] Many scholars also underline that customers' knowledge and awareness of RES are a crucial factor in the success of the CV studies (see, among others, Farhar [48]). Finally, it is well known that in European GE markets, a divergence between stated and actual consumer behavior exists [44]. To reduce this divergence, uncertainty is directly introduced in the elicitation format according to a multiple-bounded uncertainty approach [21].

The pros and cons of the GE development scenario were provided by questionnaire to respondents using a set of questions about: (i) their general knowledge, awareness and the potential development of RES in electricity production, (ii) their knowledge about the Italian energy system, (iii) WTP amounts (bids) to support the Italian GE target and (iv) respondents' attributes. In particular, respondents were first asked whether they were aware and if they believed that GE could play an important role in Italy ("unsure or do not know" options were also available):

– *Today, there is a heated debate on the opportunity to develop RES. Are you for or against RES?*
– *In your opinion, what is the Italian situation with regard to the need for energy (electricity, heating and transport) production activities?*
– *In your opinion, can the development of RES in Italy improve/worsen the current energy situation in the country?*

After the first section, respondents were asked about their knowledge of GE by answering the validity test questions. These validity questions allowed us to construct a dummy variable that concerns the accuracy of the answers provided by respondents about the scenario proposed, particularly about the degree of knowledge of RES. If the interviewee answered "yes" to the first question and correctly identified the different types of RES in the second question, the dummy variable is equal to one, zero otherwise. Afterwards, respondents were asked if they were in favor of and if they would contribute or not to RES use in electricity production for environmental reasons, according to the elicitation format.

– *Italy has committed to increasing the production of energy from renewable sources by 2020, bringing the ratio of RES to 17%. This share is of, the gross final energy consumption and if we only consider electricity generation. the target share is 26.4% How much do you support this commitment?*

Table 4
Elicitation format[a].

Bid (EUR)	DY (%)	PY (%)	DK (%)	PN (%)	DN (%)
0.05	100	75	50	25	0
0.1	100	75	50	25	0
0.15	100	75	50	25	0
0.3	100	75	50	25	0
0.5	100	75	50	25	0
0.75	100	75	50	25	0
1	100	75	50	25	0
1.5	100	75	50	25	0
2	100	75	50	25	0
5	100	75	50	25	0
10	100	75	50	25	0
15	100	75	50	25	0
20	100	75	50	25	0
30	100	75	50	25	0
50	100	75	50	25	0
100	100	75	50	25	0
200	100	75	50	25	0

[a] Instruct the respondent to circle an answer for each price.

Diagonal response patterns.

Bid (EUR)	DY	PY	DK	PN	DN
0.05	XXX				
0.1	XXX				
0.15	XXX				
0.3	XXX				
0.5		XXX			
0.75		XXX			
1		XXX			
1.5		XXX			
2			XXX		
5			XXX		
10			XXX		
15				XXX	
20				XXX	
30				XXX	
50					XXX
100					XXX
200					XXX

Fig. 1. Diagonal response patterns.

– *For the scenario described, what is the maximum amount that you are willing to pay to support RES as a surcharge on your bill? Please be careful about your degree of certainty.*

To construct a reliable WTP scenario, respondents were first asked to state the amount of their last three bills, and they were then informed of the A3 component according to Section 2.2. At the end of the questionnaire, interviewees were asked about their attributes such as demographic characteristics, age and education.

3. Theoretical and econometric framework

In the CV analysis, a policy scenario is proposed to interviewees, and their WTP for attaining the national goals is then elicited [49]. As with any CV study, there is always a risk of incurring bias [12]. However, it has also been shown in the literature that a well-designed and carefully administered survey provides consistent, coherent and credible information on WTP. In this study, the Italian household is considered as a costumer unit. In 2007, households represented 21% of the total final electricity consumption and used 65% of the total points of injection in the Italian electricity market [50].

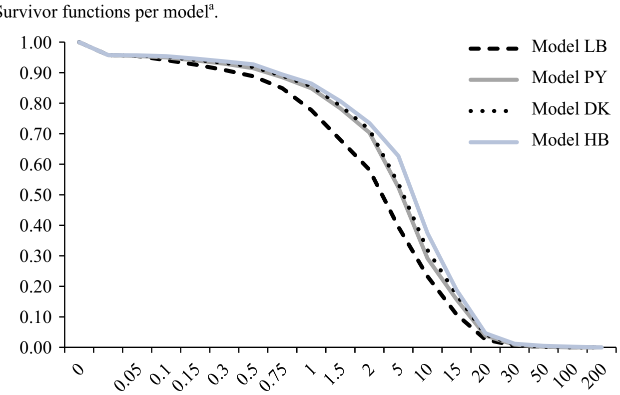
[6] Previously used guidelines suggest various ways to test for the understanding and acceptance of the scenario proposed, such as follow-up questions and test questions. One common way is to include questions whose answers should confirm each other [47].

Table 5
List of variables and descriptive statistics.

Variables		Mean	Std. dev.	Min	Max
Income (000)	Continuous variable: household yearly income.	34.82	12.01	0.15	77.46
Geo5	Categorical variable: 1=Northwest; 2=Northeast; 3=Central Italy; 4=South; 5=Islands.	2.75	1.39	–	–
D.Geo5	Dummy variable: 1 if Geo5 < 4.	0.49	0.44	–	–
D.City	Dummy variable: 1 if municipality > 100,000 inhabitants.	0.35	0.09	–	–
D.Sex	Dummy variable: 1 if male.	0.52	0.50	–	–
Age	Continuous variable: age of a respondent.	46.30	17.91	20	78
Professional category	Categorical variable: from 1 to 10.	6.03	3.24	–	–
D.Professional status	Dummy variable: 1 if professional category=enterprises or professional class.	0.22	0.45	–	–
Education	Continuous variable: number of years a respondent has attended school.	12.02	3.98	5	21
D.Higher education	Dummy variable: 1 if education > 13.	0.46	0.50	–	–
D.Scenario	Dummy variable: 1 if response < 3[a].	0.24	0.19	–	–
D.Know RES	Dummy variable: 0=wrong; 1=right[b].	0.83	0.18	–	–
Household size	Discrete variable: number of households' members.	3.13	1.22	1	6
Child	Discrete variable: number of children.	1.35	1.04	0	4
D.House	Dummy variable: 1 if family owns his house.	0.67	0.34	–	–
D.Test	Dummy variable: validity test question[c].	0.33	0.47	–	–

[a] The question is: "In your view the current Italian energy scenario will worsen in the next 10 years?" (1=extremely; 2=very; 3=rather; 4=a little; 5=not at all).
[b] Knowledge of RES: interviewee is asked to identify RES.
[c] See Section 2.3.

Survivor functions per model[a].



[a] LB = lower bound; PY = probably yes; DK = do not know; HB = higher bound.

Fig. 2. Survivor functions per model.

3.1. Theoretical model

Let us assume that households maximize their utility subject to budget constraints. The demand for GE use can be viewed as that of any other goods or services and therefore consumer choice is modeled within the utility (expenditure) maximization (minimization) framework. If we allow expenditure (E) to be a function of GE use services (R)[7] and private goods (X_P) and composite of public goods (X_G) to be subject to the utility (U) constraint, (1) is obtained (see Appendix A for further details)

$$\text{Min } E(P_P, P_R, X_G) \quad \text{sub to}: U = U(X_P, R, X_G) \tag{1}$$

where P_P and P_R, are the prices of private goods and of GE use services, respectively. Given the utility constraint, the representative household faces expenditures for GE use services, private goods and composite public goods; thus, the household will attempt to minimize the following expenditure function:

$$E = E(P_P,\ P_R,\ X_G,\ U) \tag{2}$$

[7] Litvine and Wustenhagen [51] focus on the perceived benefit as key factor to increase of purchase of GE.

However, given the characteristics of GE, it makes sense to think of this function as a restricted demand problem where the consumer does not observe P_R and chooses R, but rather is offered R and can then choose either to pay for these services (R^1) or not (R^0). Therefore, P_R is replaced with R, and the expenditure function can then be rewritten as follows:

$$E = E^{*}(P_P,\ R,\ X_G,\ U) \tag{3}$$

In such a restricted case, the WTP for GE use is simply the difference between two expenditure functions (with $R^1 > R^0$); the compensating surplus (CS) welfare estimate can be derived in terms of the difference

$$CS = E^{*}(P_P,\ R^0,\ X_G,\ U) - E^{*}(P_P,\ R^1,\ X_G,\ U) \tag{4}$$

The above estimate of the CS is a measure of the households' WTP for the GE use services, i.e., the amount that each Italian household is willing to pay without changing its utility level.

3.2. Elicitation format and econometric model

The elicitation format used in our econometric model takes into account two main issues: (i) consumers may have a whole valuation distribution in mind instead of a single-point economic value; (ii) uncertainty exists that typically affects CV studies and GE markets.

Referring to the first issue, we use a variant of the PC approach, which allows the possibility that consumers may have a range of economic values in mind. We follow the literature which shows that the PC method can be intensively employed in CV studies [52–54]. Referring to the second issue, both ex-ante and ex-post approaches to reduce hypothetical bias [12] are employed. Specifically, among ex-ante methods, we adopt a cheap talk script [55] so that participants are explicitly warned about hypothetical bias and are asked to respond to valuation questions as if the payment were actual. It is used a script similar to that of Cummings and Taylor [55] that was appropriately modified to be consistent with our scenario. Modifications are made using information reported by Murphy et al. [56] and Diaz-Rainey and Ashton [44].

Among ex-post mitigation approaches [5,7,9,10,21], a certainty correction method is adopted to reduce overestimation risk by proposing five types of acceptance intensity. These were:

Table 6
Interval data regression for WTP to support GE in Italy per model[a].

Variables	Model LB	Model PY	Model DK	Model HB
Income	0.0479	0.0611	0.0623	0.0636
	*0.0047******	*0.0053******	*0.0056******	*0.0068******
D.Geo5	0.1271	0.1598	0.1701	0.1866
	*0.0330******	*0.0400****	*0.0562******	*0.0598******
D.City	−0.0855	−0.1152	−0.1738	−0.1043
	*0.0423**	*0.0547****	*0.0908**	*0.0500****
D.Sex	−0.2905	−0.3589	−0.3418	−0.3247
	*0.1400****	*0.1607****	*0.1701**	*0.1591**
Age	−0.3487	−0.4067	−0.5331	−0.6217
	*0.0948****	*0.1040****	*0.1310****	*0.1591****
D.Professional status	0.1416	0.1612	0.1888	0.2074
	*0.0367******	*0.0421******	*0.0450******	*0.0522******
D.Higher education	0.1307	0.1451	0.2048	0.2409
	*0.0671**	*0.0755**	*0.1389*	*0.1203**
D.Scenario	−0.5251	−0.7332	−0.8045	−0.8296
	*0.2509****	*0.3605****	*0.3990****	*0.4099****
D.Know RES	0.6463	0.7700	0.7816	0.7934
	*0.4110**	*0.5099**	*0.5190**	*0.5210**
Household size	−0.1938	−0.2318	−0.2712	−0.2797
	*0.0449******	*0.0587******	*0.0643******	*0.0642******
D.Test	−0.2871	−0.2961	−0.3947	−0.4007
	*0.1403****	*0.1456****	*0.1989****	*0.1979****
Constant	0.9581	1.3124	1.4059	1.4683
	*0.2019******	*0.2598******	*0.2899******	*0.2910******
Lnsigma	0.5305	0.5471	0.5553	0.5601
	*0.0262******	*0.0279******	*0.0225******	*0.0230******
Sigma	1.6998	1.7282	1.7425	1.7508
	*0.0485******	*0.0502******	*0.0523******	*0.5509******
Obs.	1019	1019	1019	1019
McKelvey and Zavoina's R^2	0.1263	0.1302	0.1314	0.1325
LR χ^2 (11)	139.98	152.37	183.90	186.67
median WTP	4.62	7.13	7.16	8.05
[95% Conf. interval]	[4.11–5.13]	[6.55–7.71]	[6.59–7.73]	[7.32–8.93]
mean WTP	12.76	13.05	13.16	15.09
[95% Conf. interval]	[11.36–14.80]	[12.01–14.09]	[12.10–14.22]	[14.02–16.47]

Standard errors in italic.

*** Coefficient that is significant at 1% level.
** Coefficient that is significant at 5% level.
* Coefficient that is significant at 10% level.
[a] LB=lower bound; PY=probably yes; DK=do not know; HB=higher bound.

"definitely yes" and "no" (DY; DN), "probably yes" and "no" (PY; PN) and "unsure or do not know" (DK). Numerical likelihood information is used (100%; 0%), (75%; 25%) and (50%), respectively, and respondents are faced with a SPC method[8] inclusive of 17 bids from 0.05 EUR to 200 EUR and five numerical likelihoods for each bid. We asked about numerical likelihoods because the meaning of "probably yes", "unsure" and "probably no" may be perceived differently among individuals. Consequently, if the verbal likelihood is directly asked, an ambiguous interpretation of some responses could result.

Table 4 shows the elicitation format structures used in the survey in detail. The data collected may be analyzed in several ways [7,9,21,22,59].

Broberg and Brännlund's approach (BB) is applied and consequently, the probabilistic answers are recoded according to four models: (a) "higher bound", in which only DN=no, others=yes; (b) "unsure", in which DN and PN=no, others=yes; (c) "probably yes", in which DY and PY=yes, others=no and finally (d) "lower bound", in which only DY=yes, others=no. To explain this approach, it is compared with the well-known Welsh and Poe approach (WP). According to the last approach, the entire WTP interval shifts as a change in the probability statement, whereas using the BB, the interval does not entirely shift, but only the upper bound shifts, introducing uncertainty; in other words, the WTP interval is expanded instead of moved. In both approaches, each respondent's WTP lies in an interval that includes the highest WTP in WP, while in BB, each respondent's WTP is bounded by the highest bid she accepts and the lowest bid she does not accept. Consequently, the BB allows us to use the most reliable information about each respondent, without discarding certain responses [9]. This approach reduces the risk of overestimation, especially in the higher bound model.

Differences between these two approaches could be explained considering Fig. 1, which shows an example of the response pattern. In the probably yes model, the WP interval is [0.5–1.5] EUR, while in the BB, the WTP interval is [0.05–1.5] EUR, and in the higher bound model, the WTP intervals are [30–50] EUR and [0.3–50] EUR, respectively.

Higher and lower bound models set a maximum confidence interval for WTP estimates, given that they are "certainty models". These models, which use DY and DN information, constitute the extreme values of the estimated WTP [9].

According to the aim of our paper, obtaining a confidence interval of the WTP makes the results more suitable for policy analysis. Finally, we deem it appropriate to use the interval regression method because [60–62]: (a) in the BB, it is possible to treat data as interval data; (b) in our study, a limited number of respondents state a zero bid; (c) a small size of intervals is used. See Appendix B for further details on the econometric model.

[8] This method was introduced by Wang and Whittington [8]. Recently, Ichoku et al. [57] and Fonta et al. [58] used the same approach; for differences with a MBDC see Wang and He [59].

Table 7
Market sustainability of GE target per model[a].

	Measures	Model LB	Model PY	Model DK	Model HB
WTP, bimonthly per household					
Median	EUR	4.62	7.13	7.16	8.05
Mean	EUR	12.76	13.05	13.16	15.09
Annual electric bill	Nr.	6			
Number of households	Nr.	21,810,676			
Total annual WTP					
Median	Million EUR	302.3	466.5	468.5	526.7
Mean	Million EUR	1669.5	1707.2	1722.7	1975.1
Annual subsidy cost	Million EUR	3500			
Market sustainability					
Median	%	8.6	13.3	13.4	15.1
Mean	%	47.7	48.8	49.2	56.4
Annual subsidy cost (households' share)[b]	Million EUR	700			
Market sustainability					
Median	%	43.2	66.6	66.9	75.2
Mean	%	238.5	243.9	246.1	282.2

[a] LB = lower bound; PY = probably yes; DK = do not know; HB = higher bound.
[b] Using data showed in Table 3 and information provided by Regulatory Authority for Electricity and Gas [50] we estimate household share of 20% (700 million EUR) of target cost.

4. Results

The respondents show a favorable attitude with regard to RES in electricity generation. The majority of our sample believes that the Italian energy scenario will worsen in the next 10 years and considers that GE represents a strategic opportunity for Italy.

More than 80% of the respondents professed to have a "good" knowledge of RES, while 10-12% reported that they were not aware of RES. We noted that more than 80% of the respondents declared that they had a good knowledge of RES and were able to correctly identify different types of RES. This finding means that respondents have a good knowledge of GE and understand the evaluated scenario. This information is an important check for the survey. Indeed, if a respondent does not take the decision process seriously or does not understand the questions posed, his/her responses would not reveal his/her true preferences [62]. Table 5 shows the descriptive statistics of variables used. The profile of the typical interviewee is a highly educated, married 47-year-old man who lives with a family with one child. The typical family income is approximately 35,000 EUR for families that own a home.

Details of the WTP responses are presented in Fig. 2 that shows how uncertainty may affect WTP distributions. As expected, the percentage of respondents willing to pay a given amount decreases with the bid submitted. On the other hand, this percentage increases when weaker certainty levels were accepted, which is especially evident at the rightmost end of the tail for amounts greater than 5 EUR.

4.1. Estimation results

Using the BB, the parameters under the assumption of log distribution are estimated and the mean (B5) and median (B6) WTP are computed. We thus follow the literature that suggests the use of both measures [63,64], even if sometimes the median is preferred because of its robustness, reducing WTP overestimation risk or whether it is [65]: "… the tax price that was offered to subject in the elicitation format".

The estimated results confirm the prior expectations, as shown in Table 6. Variables related to respondents' characteristics explain differences in WTP for GE. Age and sex are negatively related to WTP, while income, education and professional status positively affect these estimates. These results show that younger citizens are more likely to support the target, while women are less supportive than men. As expected, citizens earning higher incomes, such as citizens that are more highly educated, support the GE target to a greater extent. Our results show that household size is negatively related to WTP, according to other studies conducted in Europe [17,32]. The empirical findings regarding the influence of geographical characteristics are mixed. Indeed, if residents in Northern and Central Italy exhibit a higher WTP, the size of the municipality is not always significant. Considering the first two sections of the questionnaire, the results show that WTP is significantly and positively influenced by knowledge of RES and by the conviction that GE could play an important role in Italy.

Finally, the dummy variable (D.test), which is a proxy of the understanding scenario, reduces actual WTP estimates, confirming that overestimation occurs if respondents do not fully understand the scenario proposed. A monetary estimation of WTP shows that median WTP lies between 4.62 EUR and 8.05 EUR every two months per household. A wider range of values is obtained using mean WTP, which is more affected by high bids (indeed, the bimonthly amount ranges from 12.76 EUR to 15.09 EUR).[9] Considering that in 2007, the bimonthly electric bill of a typical Italian household was approximately 70.5 EUR, household support of GE lies between 6.6% and 21.4% of the bimonthly bill. Similar percentages are reported by Brochers et al. [35], Zoric and Rovatin [32], while Haneman et al. [33] found that WTP was twice the bill. Finally, focusing on annual WTP at constant prices, the range is comparable to values shown in Tables 1 and 2. Indeed, the annual median WTP obtained by the lower bound model is 27.72 EUR, similar to Bollino's [17] results, and the mean annual WTP obtained with the higher bound model is equal to 90.56 EUR, which is close to Grösche–Schröder's [13] figures that were obtained according to "no nuclear scenario". Given that WTP estimates obtained using data collected before the economic crisis maintain their validity in a long-run perspective (see Section 4.2), we proceed to aggregate the household mean and median WTP to compute the total national WTP. This figure is compared to an estimate of the total annual subsidy [42] needed to comply with the EU climate change package GE goal by

[9] As a robustness check, we also estimate data according to the WP. The results confirm that the expansion approach provides more conservative estimates, a narrower confidence interval and more stable parameter estimates when we account for uncertainty. WTP estimates according to the WP are 1.3–3.7 times higher when compared to the WTP obtained by the expansion approach.

2020. It is possible to interpret this as a measure of the market sustainability of the EU climate policy.

Table 7 shows high variability in the results obtained according to the models and average index used. The mean and the median differ due to the distribution's skewness; consequently, the market sustainability ranges from 8.6% to 56.4%, using respectively the median of the lower bound model and the mean of the higher bound model.

This range of results depends on uncertainty. Indeed, comparing the models in Table 7, the impact of uncertainty on Italian target achievement can be appraised. Considering the differences between the higher and lower bound models as a proxy of the uncertainty in monetary terms, we noted that uncertainty amounts to a figure from 224.4 million EUR to 305.6 million EUR, that is, uncertainty ranges from 6.4% to 8.7% of the Italian national target. Finally, we have assumed that full incremental costs would be arbitrarily ascribed entirely to households. In this way market sustainability of the renewable national target is underestimated. In fact, if we consider all customers typologies and attribute to households only their share of the cost, market sustainability noticeably increases. Table 7 shows that households cover from 43.2% to 75.2% of the incremental cost if median WTPs and their share of the national target cost are used. Furthermore, households fully cover their share cost of national GE target by using mean WTPs. These results highlight that Italian households are actually willing to contribute to climate change policy.

4.2. Relevance of findings today

The aim of our paper is to assess if GE target, according to EU climate change policy, can be achieved with market forces in Italy. This aim is a long-run policy target that needs to be confronted with a stable WTP supported by actual households because sound policy analysis should be based on reliable and constant structural preference parameters, without being affected by exceptional events. Our survey, in this respect, fits this objective quite well because it was administered at the end of November 2007. The financial crisis that began at the end of 2007 led to a deep and prolonged global economic downturn that later significantly altered consumers' long-run perception and inevitably changed citizens' spending decisions. Since our data refer to the pre-crisis period characterized by macroeconomic stability, they have the necessary characteristics for a long-term policy evaluation. According to the literature, it is doubtful whether an economic downturn reduces WTP for environmental goods. Recently, Loureiro and Loomis [66] highlighted that in the period between 2006 and 2009, WTP estimates for environmental damage (the Prestige oil spill in Spain) were reduced by half, even though this reduction did not affect regions that were more directly involved in the environmental disaster. The authors explain this finding by analyzing the economic crisis: in 2009, Spain's yearly gross domestic product dropped 4% and negative figures were expected for 2010. On the contrary, in 2009, Haneman et al. [33] estimated a very high WTP to support GE in Spain. The authors used the forthcoming Copenhagen summit to justify this result. Controversial results were also obtained by Metcalfe and Baker [67]. They compared two identical surveys conducted in 2008–2010 for environmental improvement in the water sector. Their results suggest that economic downturn consistently dropped WTP elicited by PC, but did not reduce WTP elicited by CV. The few studies on the impact of the economic downturn on WTP provide conflicting results. Nevertheless, Metcalfe and Baker's [67] show some sensitivity of the PC method to the economic crisis. Considering that a variant of the PC method is utilized it becomes crucial to use pre-crisis data and consequently we deem it appropriate to use our data to elicit a stable WTP structure over time, not affected by exceptional shocks.

5. Conclusions

In Europe, current energy policy aims to increase the share of renewables in the electricity generation mix. In Italy, the goal is to attain 26.4% of electricity production from RES. Accordingly, this paper has investigated Italian households' WTP to attain this EU climate change policy. Our survey highlights an appreciable knowledge of RES and a broad consensus for the development of GE. The annual WTP is estimated, in conservative way, from 302.3 million EUR to 526.7 million EUR, which is a share of between 8.6% and 15.1% of the cost of achieving the national target; these figures noticeably increase if we ascribe to the households only their cost share. In addition, we estimate that monetary value uncertainty amounts to

Table C1
Survey respondent and country resident characteristics.

Variables	Survey respondents	Country residents
Gender		
Male	47.78%	48.40%
Female	52.22%	51.60%
Macro regions		
Northwest	26.11%	26.21%
Northeast	19.69%	18.66%
Central Italy	19.64%	19.14%
South, Sicily and Sardinia	34.55%	36.00%
Municipality size		
≤5000	17.47%	18.58%
5001–10,000	13.67%	14.11%
10,001–30,000	23.69%	22.81%
30,001–100,000	21.96%	21.29%
100,001–500,000	11.65%	10.98%
>500,000	11.55%	12.23%
Age		
15–17	3.55%	3.54%
18–24	9.92%	9.53%
25–34	16.78%	17.98%
35–44	18.85%	17.77%
45–54	16.68%	15.52%
55–64	14.36%	13.89%
>64	19.84%	21.77%
Marital status		
Single	27.99%	27.76%
Divorced	1.14%	1.23%
Separated	1.58%	1.92%
Married or cohabiting	61.75%	61.19%
Widowed	6.71%	7.90%
Status not response	0.84%	–
Education		
None and primary school	33.50%	31.16%
Secondary school and professional training	35.60%	32.50%
High school	23.90%	29.30%
University	7.00%	7.04%
Income (€)		
Mean	28,658.80	24,893.70
Quantiles 10%	98,22.22	89,18.90
25%	14,801.18	13,175.46
50%	24,682.57	20,152.32
75%	34,088.30	30,998.86
90%	47,981.99	44,049.82
Professional status		
Entrepreneurs	2.30%	1.36%
Professional class	2.10%	1.83%
Cooperative members	1.92%	1.36%
Self employed	5.70%	6.92%
Civil servant and earning employee	33.27%	31.45%
Unemployed workers	4.05%	5.62%
Students	12.44%	11.34%
Housewives	13.38%	15.30%

Table C1 (*continued*)

Variables	Survey respondents	Country residents
Pensioners	23.89%	20.64%
Others	0.96%	4.17%
Household size (members)		
1	10.71%	24.89%
2	23.20%	27.08%
3	23.74%	21.58%
4	32.03%	18.96%
5	8.49%	5.80%
6 or more	1.83%	1.69%

9% of the cost of achieving the target. Finally, an analysis of the A3 burden shows that the actual additional cost to consumers for supporting GE is less than the WTPs obtained in our models. This means that a further margin could exist for additional policy actions to implement appropriate education campaigns, aimed at providing information to reduce the uncertainty that affects the GE market.

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Appendix A. Theoretical model

Let us consider a household's direct utility function

$$U = U(X_P,\ R,\ X_G) \tag{A1}$$

This function is positively related to the private goods X_P (X_{P1}, …, X_{PN}), the composite public good X_G and the public good R (GE use services). X_G is a composite commodity of all public goods with unit prices and values equal to the tax charged to the household. Households maximize U subject to their budget constraints, that is

$$M = X_P P_P + X_G \tag{A2}$$

where M is the nominal income and P_P is a price vector of private goods. Each household spends all of its disposable income by purchasing private goods

$$Md = M - X_G \tag{A3}$$

A maximization framework provides a set of conditional demand functions

$$d_i^* = d(P_P,\ P_R,\ X_G,\ Md) \tag{A4}$$

By substituting d_i^* into U, we obtain a conditional indirect utility function

$$V = V(P_P,\ P_R,\ X_G,\ Md) \tag{A5}$$

Inverting V for Md, we obtain the conditional expenditure function

$$E^* = Md = E^*(P_P,\ P_R,\ X_G,\ U) \tag{A6}$$

Minimizing the expenditures on both private and public goods subject to the utility level, we obtain the restricted expenditure function

$$E = E(P_P,\ P_R,\ X_G,\ U) \tag{A7}$$

The conditional expenditure function and the restricted expenditure function are related as follows:

$$E(P_P,\ P_R,\ X_G,\ U) = E^*(P_P,\ P_R,\ X_G,\ U) + X_G \tag{A8}$$

We assume that the consumer does not observe P_R and chooses R, but rather is offered R and can choose to pay for it or not. Therefore, P_R is replaced with R, and we can rewrite the relationship as follows:

$$E(P_P,\ R,\ X_G,\ U) = E^*(P_P,\ R,\ X_G,\ U) + X_G \tag{A9}$$

By changing the energy scenario, we assume that the restricted expenditure function varies according to R: R^0 = scenario without GE in the energy portfolio and R^1 = scenario with GE in the energy portfolio. By holding M constant, we find that the WTP for the use of RES in electricity production is given by the CS

$$CS = E(P_P,\ R^0,\ X_G^0,\ U^0) - E(P_P,\ R^1,\ X_G^0,\ U^0) \tag{A10}$$

$$CS = [E^*(P_P,\ R^0,\ X_G^0,\ U^0) + X_G^0] - [E^*(P_P,\ R^1,\ X_G^0,\ U^0) + X_G^0] \tag{A11}$$

$$CS = E^*(P_P,\ R^0,\ X_G^0,\ U^0) - E^*(P_P,\ R^1,\ X_G^0,\ U^0) \tag{A12}$$

where U^0 is the utility level of the household without the GE program. This estimate of the compensating surplus is a measure of the WTP for the GE use service.

Appendix B. Econometric model

Following Broberg and Brännlund [9] and Cameron and Huppert [60], the WTP probability associated with the choice of the respondent is

$$P(t_i) = P(t_{li} < \mathrm{WTP}_i \le t_{ui}) \tag{B1}$$

Because WTP is non-negative and its distribution is skewed, we use a lognormal conditional distribution

$$\log\ \mathrm{WTP}_i = x_i'\beta + e_i \tag{B2}$$

where ε_i is distributed normally, with zero mean and standard deviation σ. The probability of choosing t_i can be written as

$$P(t_i) = \Phi((\log\ t_{ui} - x_i'\beta)/\sigma) - \Phi((\log\ t_{li} - x_i'\beta)/\sigma) \tag{B3}$$

where Φ is the standard normal cumulative density function. For each model, the corresponding log likelihood function can be written as

$$\log\ L = \sum_i \log\ [\Phi((\log\ t_{ui} - x_i'\beta)/\sigma) - \Phi((\log\ t_{li} - x_i'\beta)/\sigma)] \tag{B4}$$

We estimate the optimal values of β and σ and the mean and median WTP [64]

$$\text{median WTP} = \exp(x_i'b) \tag{B5}$$

$$\text{mean WTP} = \exp(x_i'\beta)\exp(\sigma^2/2) \tag{B6}$$

and we compute the confidence interval by bootstrap methods with 3000 replications.

Appendix C. Statistical details

Table C1 provides all of the characteristics of the sample and shows that the sample is highly representative of the Italian population in terms of the male–female ratio, geographical and urban locations, demographic characteristics, education and income distribution.

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